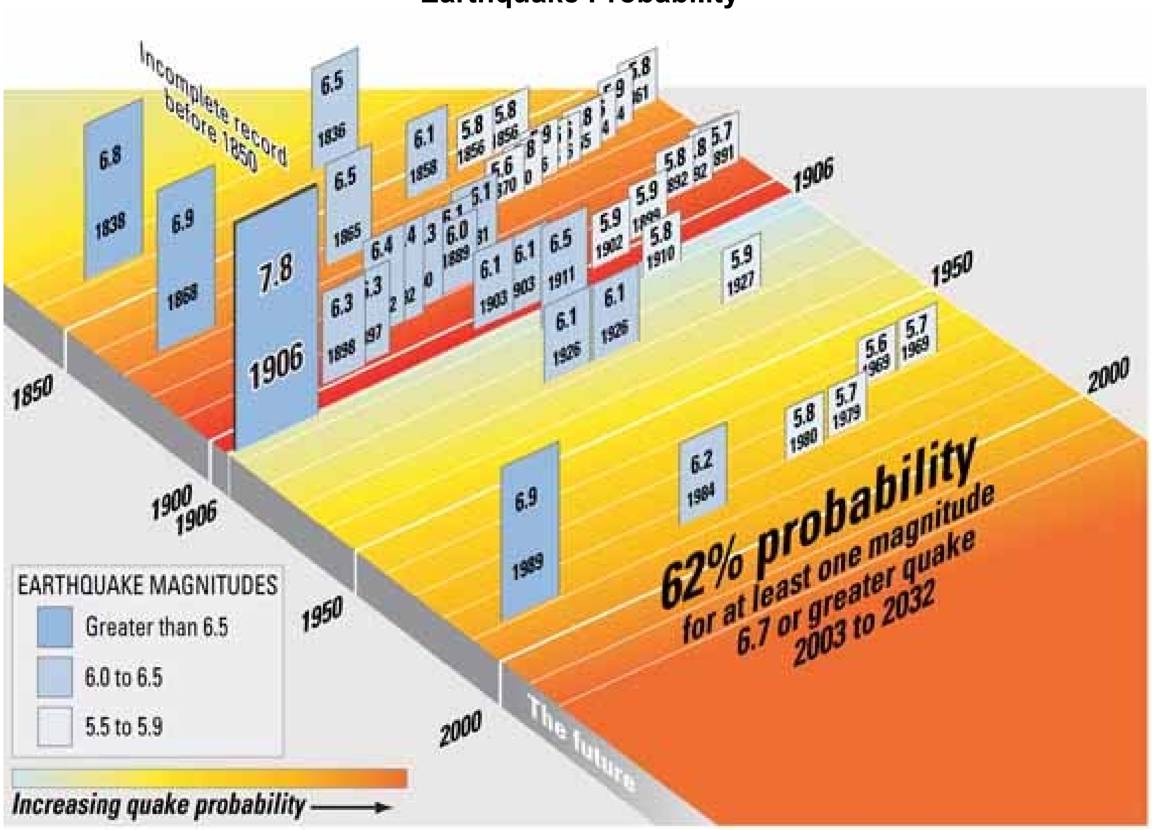
1. INTRODUCTION

Thousands of earthquakes occur every year around the San Francisco Bay Area. While most of the earthquakes go unnoticed, the Bay Area is highly susceptible to an earthquake of damaging magnitude on any number of local area faults. The U.S. Geological Survey (USGS) estimates that there is a 62 percent chance that a magnitude (M) 6.7 or larger earthquake will occur in the region before 2032 as illustrated in Figure C.2-1. This annex provides reference material for the Hayward Fault and describes the means for characterizing earthquakes and the risks associated with earthquakes in the Bay Area.

Figure C.2-1
Earthquake Probability



Source: Putting Down Roots in Earthquake Country, USGS, 2005

1.1. Nature

An earthquake is due to movement, generally sudden, along a geologic fault, which results in a release of strain accumulated within or along the edge of the earth's tectonic plates. The effects of an earthquake can be felt far beyond the site of its occurrence. Earthquakes usually occur without warning and, after just a few seconds, can cause massive damage and extensive casualties. The most common effect of an earthquake is ground motion – that is, the vibration or shaking of the ground during an earthquake.

Ground shaking is caused by waves in the earth's interior, also known as seismic waves, and along the earth's surface, known as surface waves.

The severity of an earthquake can be expressed in terms of intensity. Intensity is based on the damage and observed effects on people and the natural and built environment. It varies from place to place depending on the size and rupture characteristics of the earthquake, the distance from the event, the properties of the earth in which the seismic waves travel and the local geographic conditions. Intensity generally increases with the amount of energy released and decreases with distance from the fault of the earthquake. The scale most often used in the United States to measure intensity is the Modified Mercalli Intensity (MMI) scale. As shown in Table C.2-1, the MMI scale consists of 12 increasing levels of intensity that range from imperceptible to catastrophic destruction. Peak ground acceleration (PGA) is used as a measure of earthquake ground shaking. PGA is often expressed in terms of the acceleration due to gravity, or g.

Magnitude is a measure of an earthquake's strength. It is related to the amount of seismic energy released by the earthquake's fault. Magnitude is based on the amplitude of the earthquake waves recorded on instruments.

Table C.2-1 shows the characteristic differences between magnitude, intensity, and PGA and provides context for these concepts in terms of the shaking felt.

Table C.2-1
Magnitude / Intensity / Ground Shaking Comparisons

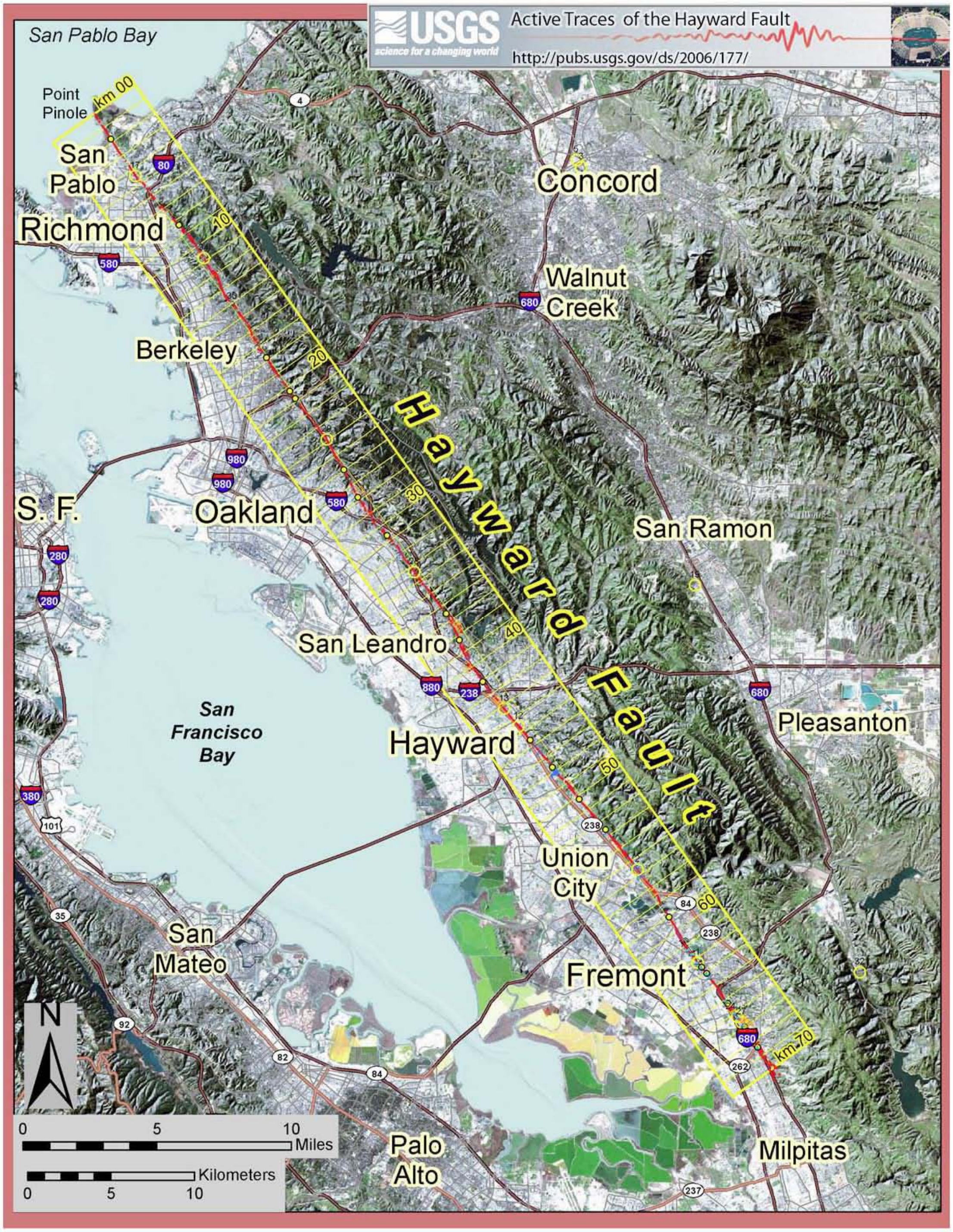
Magnitude	Intensity	PGA (% *g*)	Perceived Shaking
1.0 – 3.0	I	<0.17	Not Felt
3.0 – 3.9	II-III	0.17 – 1.4	Weak
4.0 – 4.9	IV	1.4- – 3.9	Light
	V	3.9 – 9.2	Moderate
5.0 – 5.9	VI	9.2 – 18	Strong
	VII	18 – 34	Very Strong
6.0 – 6.9	VIII	34 – 65	Severe
	IX	65 – 124	Violent
	X	124 +	Extreme
7.0 +	XI		
	XII		

Source: USGS 2006

1.2. History

The Hayward fault runs through some of the most densely populated regions of the San Francisco Bay Area, and has a high probability of failing with a magnitude 7+ earthquake within the next 30 years. Figure C.2-2 identifies the location of the Hayward Fault in the East Bay.

Figure C.2-2
Location of Hayward Fault



Source: http://quake.usgs.gov/research/geology/hf_map/pdf/hf_pagesized.pdf

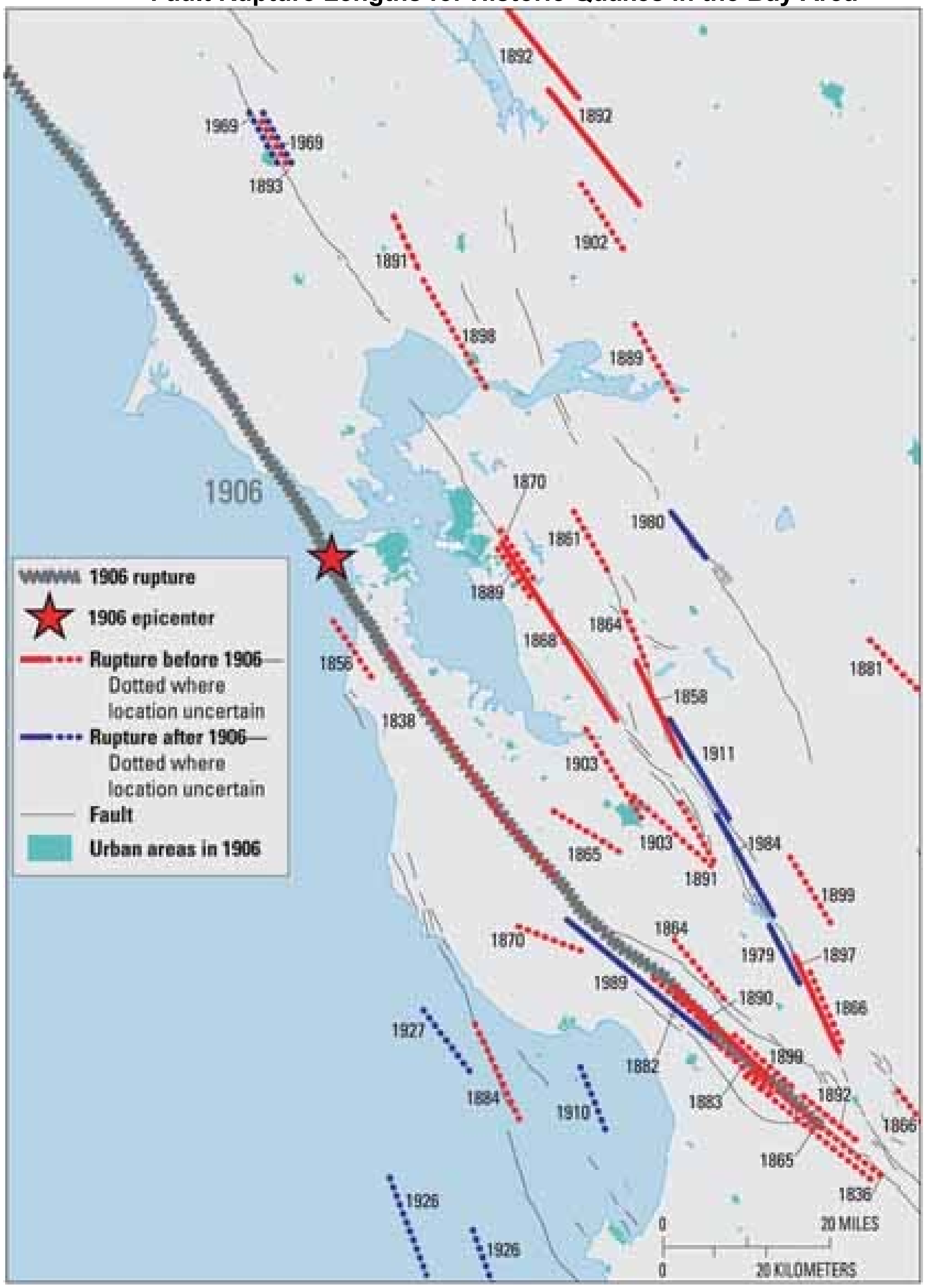
The last major earthquake on the Hayward fault occurred in 1868. In 1868, the Hayward fault ruptured along 31 miles of its length, with an average offset of 6' of right-lateral strike-slip motion. This earthquake caused considerable damage in the East Bay and San Francisco, and was known as the "Great San Francisco Earthquake" until the 1906 San Francisco earthquake.

Some seismologists believe that the 1906 San Andreas earthquake reduced the stress on many faults in the Bay Area, including the Hayward Fault, thus contributing to a quiet period along the fault. Since the 1906 San Andreas earthquake, there have been no moderately strong earthquakes on the Hayward Fault.

The activity of the Hayward fault from the south Bay to Point Pinole where the Hayward Fault enters San Pablo Bay, occur in clusters, or patches, that are spaced, on average, 6 miles apart. These patches are from 1 to 5 miles in length and are separated by quiet regions, or gaps, in which there is very little activity by comparison. The largest events on the Hayward fault in the last few years include an M 4.1 earthquake near Richmond in 1998 and M 4.2 earthquake in 1994.

The following Figure C.2-3 identifies fault rupture lengths for historic quakes in the Bay Area including the Hayward Fault.

Figure C.2-3
Fault Rupture Lengths for Historic Quakes in the Bay Area



Source: Putting Down Roots in Earthquake Country, USGS, 2005

1.3. Location, Extent, and Probability of Future Events

The Bay Area is exposed to seismic hazards from numerous known faults and potentially tons of unmapped or undiscovered faults. Most of the major faults in the Bay Area are strike-slip faults, where the rupture plane is oriented vertically and the ground on one side of the fault slips horizontally past the ground on the other side of the fault. There are, however, several thrust or reverse faults in the Bay Area, where ground on one side of the fault moves upward and over the opposing side of the fault. The most active strike-slip fault in the region is the San Andreas Fault, which has 10 major known fault segments. The Hayward Fault is also a strike-slip fault. Table C.2-2 lists the major known faults located within the Bay Area region.

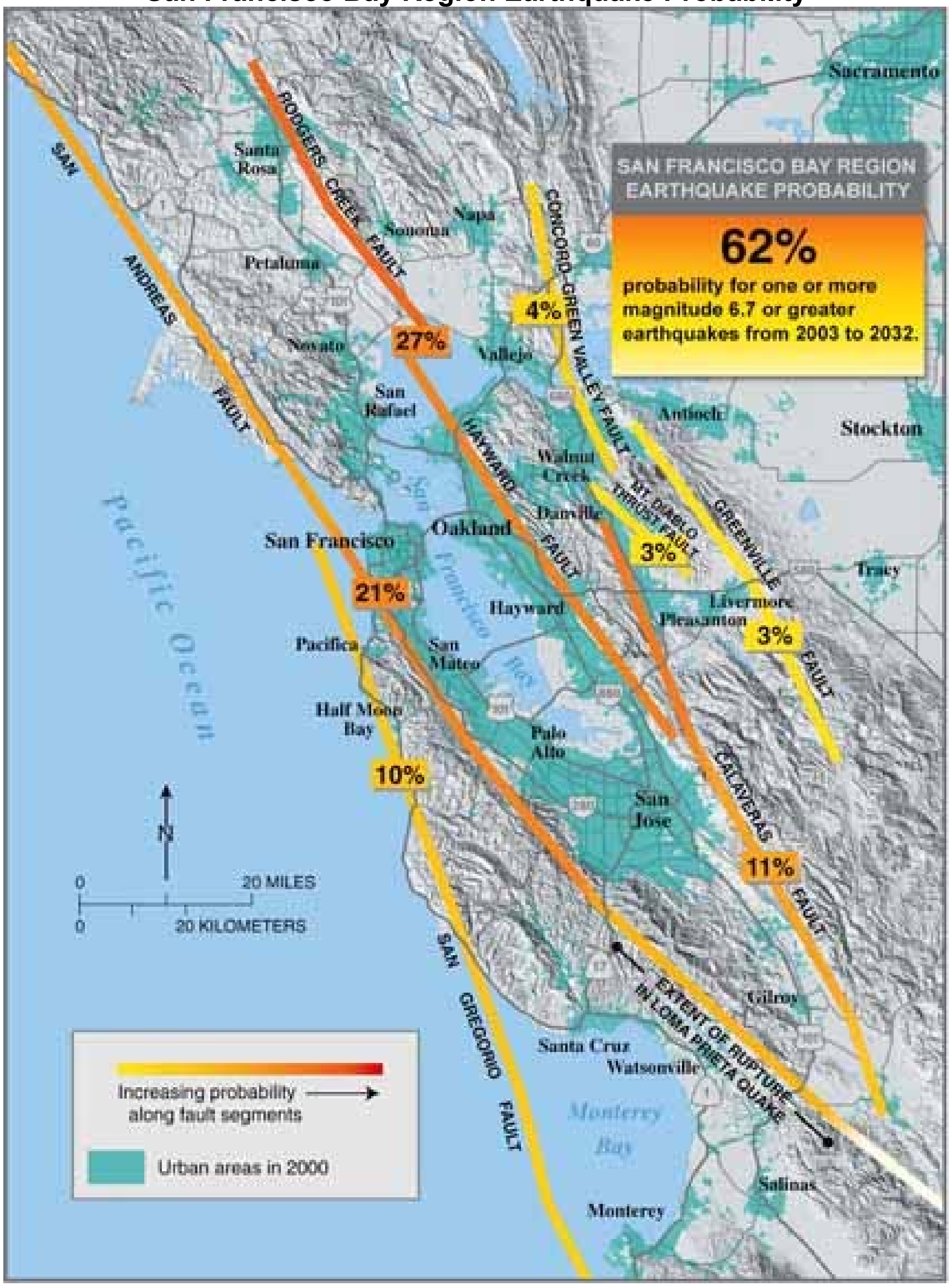
Table C.2-2
Major Known Faults in the San Francisco Bay Area Region

Name	Location	Length	Most Recent Significant M > 6.5 Earthquakes
San Andreas Fault	Gulf of California to Mendocino	1,000 km	1906
Concord Fault	Contra Costa, Solano Counties	18 km	Holocene
Calaveras Fault	Alameda, Contra Costa Counties	45 km	1160 - 1425
Hayward Fault	Alameda, Contra Costa, Marin Counties	42 km	1868
San Gregorio Fault	Marin, Monterey, San Mateo, Santa Cruz Counties	130 km	1270 - 1776
Rodgers Creek Fault	Sonoma County	56 km	1640 - 1776
Greenville Fault	Contra Costa, Alameda, San Clara Counties	147 km	Holocene
Mt. Diablo Thrust Fault	Contra Costa County	8 km	Late Quaternary

Source: USGS 2005

In 2002, the USGS determined with a 62 percent probability that a M 6.7 or greater earthquake will strike the region by 2031 as illustrated in Figure C.2-4.

Figure C.2-4
San Francisco Bay Region Earthquake Probability



Source: Putting Down Roots in Earthquake Country, USGS, 2005

Table C.2-3 shows the 10 most likely damaging earthquake scenarios in the region over a 30-year period.

Table C.2-3
Ten Most Likely Damaging Earthquake Scenarios

Fault	30-Year Probability (Percent)	Mean Magnitude (M)
Rodgers Creek Fault	15.2	7.0
Northern Calaveras Fault	12.4	6.8
Southern Hayward Fault	11.3	6.7
Northern and Southern Hayward Fault	8.5	6.9
Mt. Diablo Thrust	7.5	6.7
Green Valley – Concord Fault	6.0	6.7
San Andreas Fault, North Coast segment	4.7	7.9
San Andreas Fault, Peninsula segment	4.4	7.2
San Gregorio Fault, Northern segment	3.9	7.2
San Andreas Fault, Peninsula and Santa Cruz segment	3.5	7.4

Source: USGS 2003

1.4. Effects – Shaking

Damage in an earthquake is primarily from shaking. The intensity of shaking a structure will experience during an earthquake is a function of three factors:

- **Magnitude** - the measure of the earthquake strength. Therefore, the bigger the earthquake, the more energy is released and the more intense shaking is felt.
- **Distance** - earthquake waves diminish in intensity as they travel through the ground, so earthquake shaking is generally less intense farther from the fault.
- **Location** - soil conditions can also affect shaking. Shaking can become amplified in areas of soft soils and fill.

A significant tool available to estimate the potential range of impacts of an earthquake is “ShakeMap", developed by the USGS. ShakeMap uses the sensor information from the Advanced National Seismic System to map actual ground shaking intensity in near real-time after an event. The program is capable of producing a color-coded map of the shaking intensity produced over a region and posting the map to the Internet within 60 minutes of an earthquake. The color-coding of the map is based on the MMI Scale. Table C.2-4 shows the color-coding used to identify shaking intensity on shake maps.

Table C.2-4
Modified Mercalli Shaking Intensity Scale

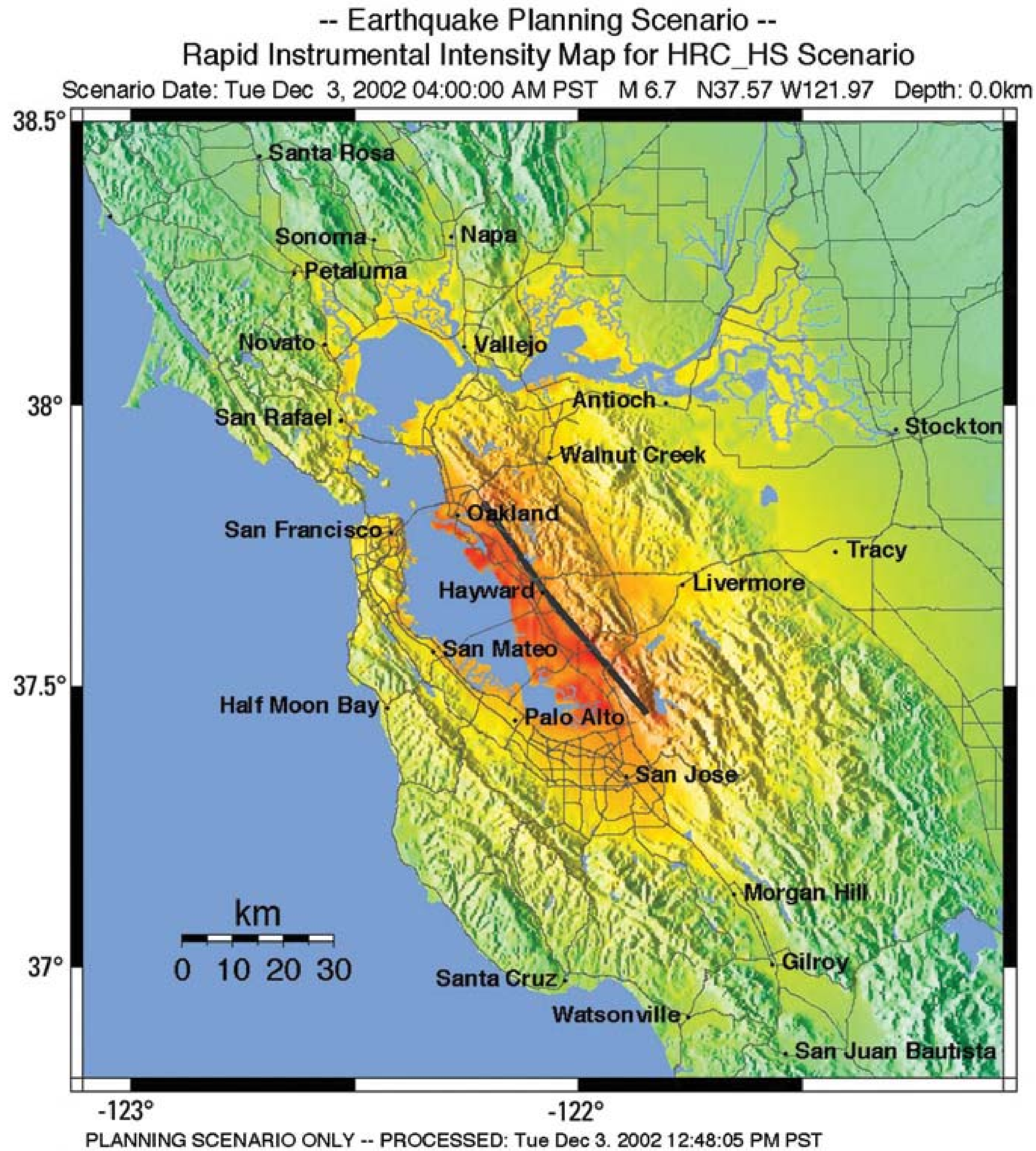
Shake Map Color	Intensity (MMI) Value	Perceived Shaking	Potential Damage	Full Impact Description
White	I	Not Felt	None	NONE.
Light Blue/Aqua	II	Weak	None	Felt by people at rest on upper floors.
Aqua/Light Green	III	Weak	None	Felt indoors, hanging objects sway, vibration like passing truck.
Light Blue/Green	IV	Light	None	Hanging objects sway, vibration like a heavy truck passing.
Green/Yellow	V	Moderate	Very Light	Felt outdoors, sleepers wakened, liquids spill, small, unstable objects displaced or upset.
Yellow/ Light Orange	VI	Strong	Light	Felt by all, many frightened, run outdoors. Windows break, dishes & books fall off shelves, pictures fall.
Light Orange/Dark Orange	VII	Very Strong	Moderate	Difficult to stand, drivers' notice, furniture moved, cracks in masonry, weak chimneys break.
Dark Orange/ Light Red	VIII	Severe	Moderately Heavy	Difficulty steering cars, damage to masonry, partial collapse of stucco and some masonry walls. Chimneys fall. Frame structures move relative to foundation.
Light Red/ Medium Red	IX	Violent	Heavy	General panic, older masonry buildings destroyed or heavily damaged. Frame structures shift off foundation if not bolted. Underground pipes broken.
Medium Red/Deep Red	X	Extreme	Very Heavy	Most masonry and frame structures destroyed with their foundations. Some well-built wood frame structures destroyed. Serious damage to dams, dikes. Large landslides.
Deep Red	XI	Extreme	Very Heavy	Rails bent greatly, underground pipelines completely out of service.
Deep Red	XII	Extreme	Very Heavy	Damage nearly total.

Source: USGS, 2006

1.5. ShakeMaps

ShakeMaps have been created for the Hayward Fault based on a M6.9 earthquake. Figure C.2-5 identifies a ShakeMap for the Hayward Fault

Figure C.2-5
ShakeMap –Hayward Fault M6.9 Earthquake



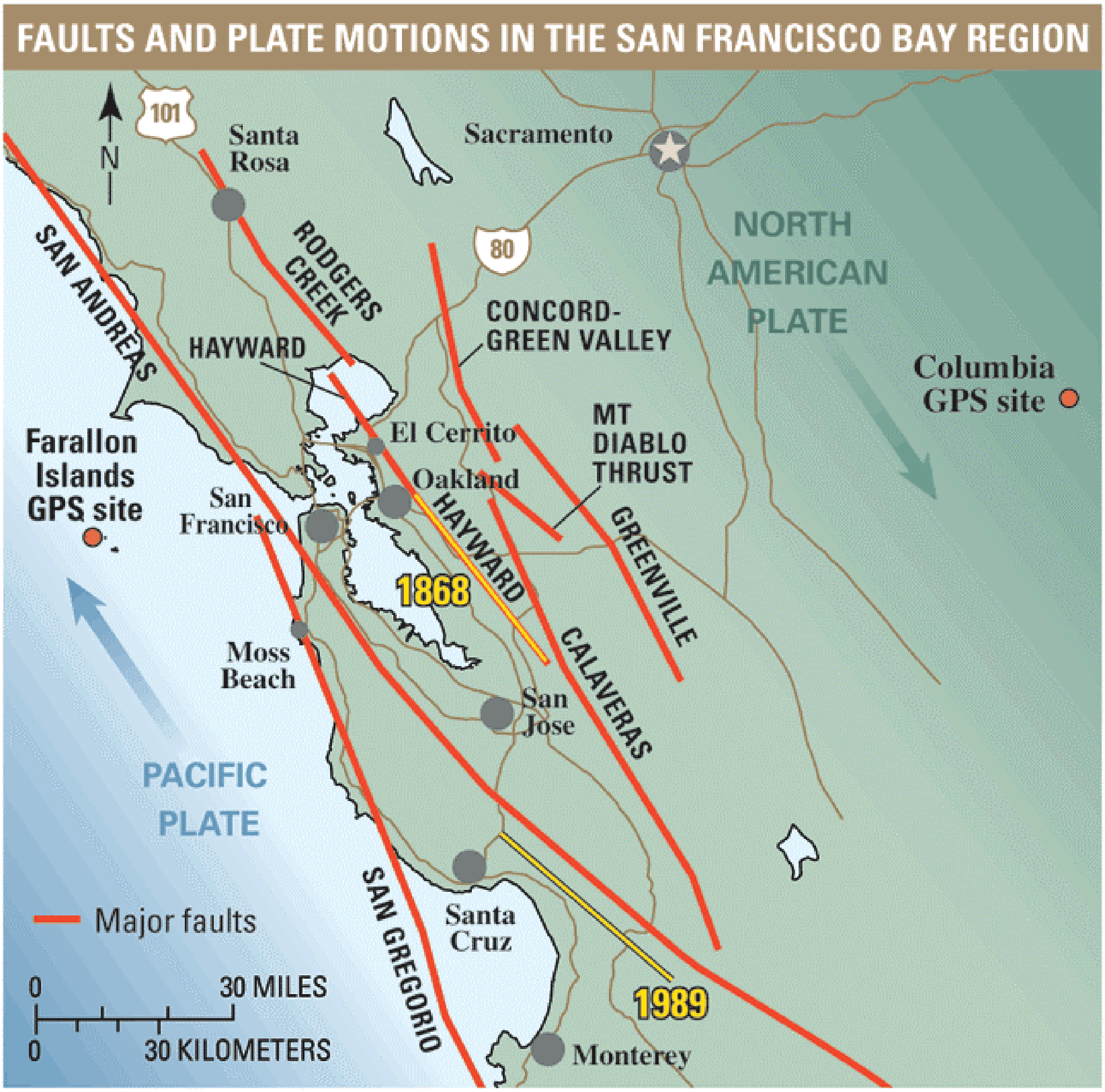
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
MODIFIED MERCALLI INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Source: USGS, 2006

1.6. Faults in the San Francisco Bay Area

The following figure (Figure C.2-6) identifies the faults and plate motion in the San Francisco Bay Area. Located on the map is the Hayward fault in proximity to other faults in the Bay Area.

Figure C.2-6
Faults and Plate Motion in the San Francisco Bay Region



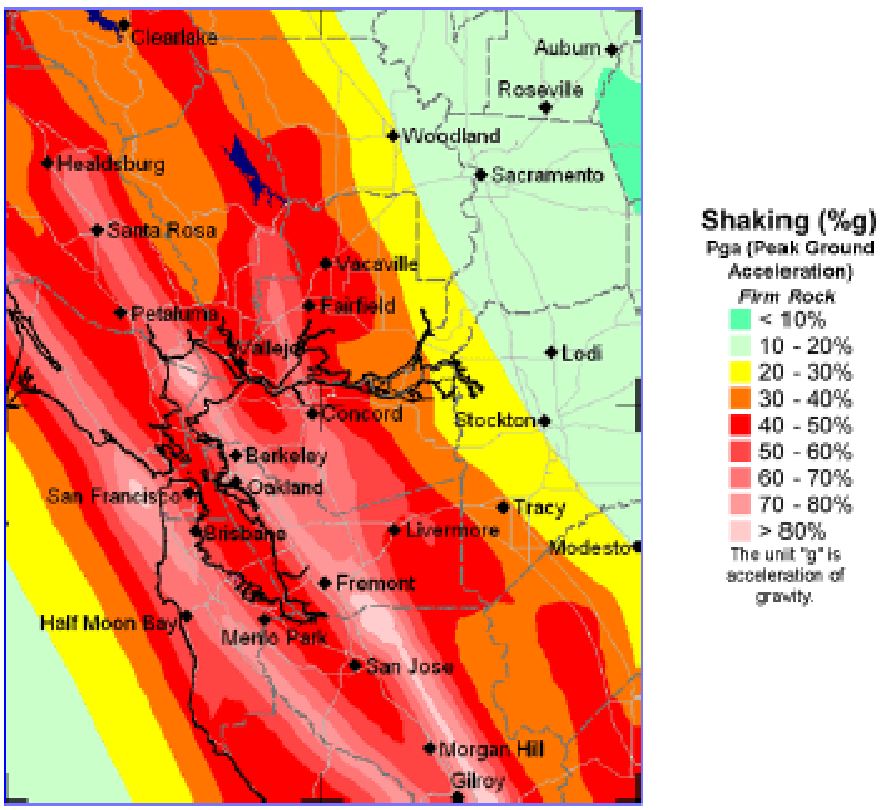
Source: USGS, 2006

1.7. Probabilistic Seismic Hazard Map

A probabilistic seismic hazard map is a map that shows the hazard from earthquakes that geologists and seismologists agree could occur in California. It is probabilistic in the sense that the analysis takes into consideration the uncertainties in the size and location of earthquakes and the resulting ground motions that can affect a particular site. The maps are typically expressed in terms of probability of exceeding a certain ground motion. For example, the 10% probability of excedance in 50 years maps depicts an annual probability of 1 in 475 of being exceeded each year. This level of ground shaking has been used for designing buildings in high seismic areas.

Figure C.2-7 identifies the bands of highest expected shaking following a major earthquake.

Figure C.2-7
Probabilistic Seismic Hazard Map

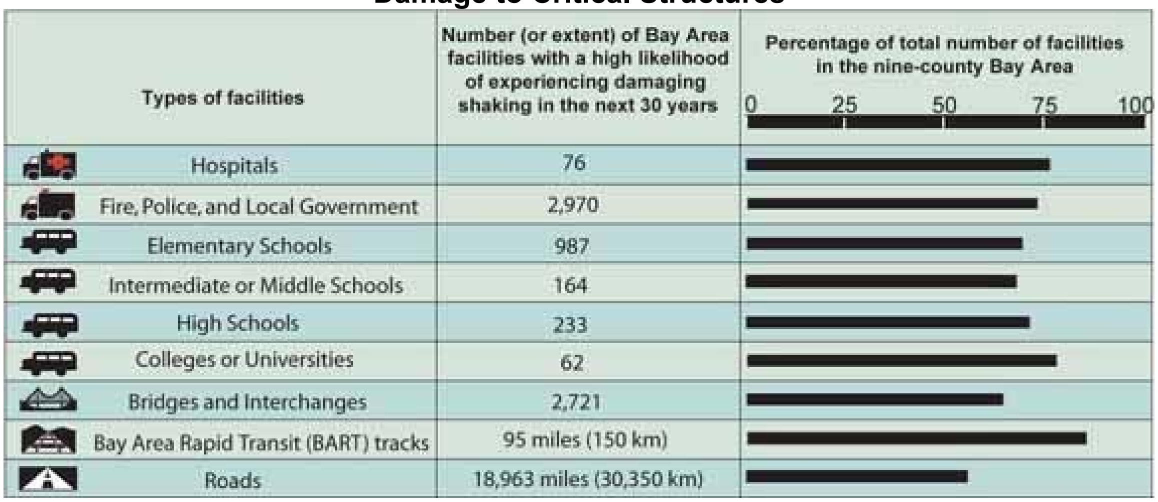


Source: www.seiamic.ca.gov/pub/intensitymaps/sfbay_county_print.pdf

1.8. Shaking - Critical Structures

Many critical structures will likely experience damaging earthquake shaking over the next thirty years in the San Francisco Bay Area. Figure C.2-8 illustrates the likelihood of damage to these facilities

Figure C.2-8
Damage to Critical Structures



Types of facilities	Number (or extent) of Bay Area facilities with a high likelihood of experiencing damaging shaking in the next 30 years	Percentage of total number of facilities in the nine-county Bay Area 0 25 50 75 100
Hospitals	76	
Fire, Police, and Local Government	2,970	
Elementary Schools	987	
Intermediate or Middle Schools	164	
High Schools	233	
Colleges or Universities	62	
Bridges and Interchanges	2,721	
Bay Area Rapid Transit (BART) tracks	95 miles (150 km)	
Roads	18,963 miles (30,350 km)	

Source: Putting Down Roots in Earthquake Country, USGS, 2005

The following table (Table C.2-5) identifies the probability of damage to transportation facilities due to a Hayward earthquake. Probabilities are based on age of the building, building codes used, retrofits to the facility and proximity to structures that could topple over during an earthquake. Probabilities range from high, medium and low. Damage could range from minor damage to major damage to un-usable facilities.

Table C.2-5
Probability of Damage Due to a Hayward Earthquake of M6.9

Entity	Street Address	Coordinates	Probability
TRANSIT SYSTEMS			
VTA (Santa Clara Valley Transportation Authority)			
Headquarters – River Oaks	3331 North First Street, San Jose, CA 95134-1906	N37 24.115 W121 56.374	Low
Guadalupe Light Rail Facility & EOC	101 West Younger Avenue San Jose, CA 95110	N37 21.277 W121 54.361	High
Cerone Bus Facility	3990 Zanker Road San Jose, CA 95134	N37 25.147 W121 56.339	Low
Chaboya Bus Facility	2240 South 7th Street San Jose, CA 95112	N37 18.357 W121 51.40	Low
North Yard Bus Facility	1325 La Avenida Street Mountain View, CA 94040	N37 24.804 W122 04.575	Low

Entity	Street Address	Coordinates	Probability
Track section	After an earthquake, VTA would stop all the services and would run them at very reduced speeds. Most of stations are retrofitted with half inch tolerance that would keep the track away from the track.		NA
Caltrain			
Headquarters	1250 San Carlos Ave., PO Box 3006, San Carlos, CA 94070-1306	N37 30.372 W122 15.704	Low
Dispatch – EOC – Operations Center	510 West San Fernando San Jose, CA 95110	N37 19.752 W121 54.018	Low
New Maintenance Center	West Taylor and Stockton San Jose, CA	N37˚ 20'26.30" W121˚ 54'48.35"	Low
Diridon Station	65 Cahill Street San Jose, CA	N37˚ 46'34.46" W122˚ 23'38.04"	High
Santa Clara Station		N37˚ 19'48.85" W121˚ 54'07.87"	High
San Francisco Station	4th and King San Francisco, CA	N37˚ 21'17.16" W121˚ 56'14.52"	Low
Bridges and Overpasses	Various locations - There are 27 bridges and approximately 15 highways over crossings that could be expected to fail.		NA
SamTrans			
Headquarters - EOC	1250 San Carlos Ave., PO Box 3006, San Carlos, CA 94070-1306	N37 30.372 W122 15.704	High
Bus Facility	301 North Access Road San Francisco, CA	N37 38' 13.37 W122 23' 15.52	Medium
Bus Facility	501 Picko San Carlos, CA	N37 30' 56.85 W122 15' 02.94	Medium
Bus Facility	934 Brewster Redwood City, CA	N37 29' 24.11 W122 13' 58.60	Medium
Trains	Trains run all the way from San Francisco to Gilroy. They would be shut down until the investigation of the tracks and the weak links would be the underpasses and overpasses which are more likely to fail.		NA
Transbay Terminal	427 Mission Street San Francisco, CA	N37 47.417 W122 23.809 Or N37 47.380 W122 23.786	Low
San Francisco Municipal Railway (Muni)			
Main Offices	1 S. Van Ness Avenue, San Francisco, CA	N37 46.750 W122 25.206	High
Cable Car Division	Cable Car Museum 1201 Mason Street San Francisco, CA 94108	N37 47.672 W122 24.685	High
Maintenance Facility	700 Pennsylvania Avenue San Francisco, CA	N37 45.442 W122 23.587	High
Power Control Facility	2502 Alameda Street San Francisco, CA	N37 46.095 W122 24.583	High
Flynn Division (articulated buses)	1940 Harrison Street San Francisco, CA	N37 45.927 W122 24.787	High
Potrero and Street Operations	2500 Mariposa Street San Francisco, CA	N37 45.790 W122 24.479	Medium
Woods Division	1001 22nd Street San Francisco, CA	N37 45.466 W122 23.471	Medium

Entity	Street Address	Coordinates	Probability
Woods Maintenance	1095 Indiana San Francisco, CA	N37 45.374 W122 23.461	Medium
Green Division (light rail facility)	425 Geneva Avenue San Francisco, CA	N37 43.269 W122 26.849	Low
Geneva Division	2310 San Jose Avenue San Francisco, CA	N37 43.244 W122 26.796	Low
Presidio Division	2600 Geary San Francisco, CA	N37 46.955 W122 26.751	Low
Presidio Offices	949 Presidio San Francisco, CA	N37 46.986 W122 26.757	Low
Kirkland Division	2310 Stockton San Francisco, CA	N37 48.429 W122 24.630	NA
Operations Central Control - EOC	131 Lennox Way San Francisco, CA	N37 44.512 W122 27.927	Low
Mint Yard (rail storage yard – streetcar)	1 Buchannan San Francisco, CA	N37 46.190 W122 25.616	NA
Scott Division (non-revenue vehicles)	1849 Harrison San Francisco	N37 46.080 W122 24.861	NA
Marin Division (bus storage and track storage)	1395 Marin San Francisco, CA	N37 44.929 W122 23.419	NA
MTA Security Division	875 Stevenson, Suite 204 San Francisco, CA	N37˚ 46’34.02” W122˚25’00.21”	NA
Power Control Substation	505 Illinois Street San Francisco, CA	N37˚ 45’53.82” W122˚23’16.26”	NA
Power Control Substation	702 Phelps Street San Francisco, CA	N37˚ 44’27.92” W122˚23’25.15”	NA
Power Control Substation	3400 Keith Street San Francisco, CA	N37˚ 43’10.52” W122˚23’54.12”	NA
Track section	No comment on unavailable track section		NA
Golden Gate Transit District			
Headquarters – San Rafael Bus Yard	1011 Anderson Dr, San Rafael, CA, 94901	N37 57.345 W122 30.302	Medium
EOC	Toll Plaza Administration Building SF Side of Hwy 101 San Francisco, CA	N37 48.528 W122 28.621	Medium
Santa Rosa Bus Yard	3225 Industrial Way Santa Rosa, CA	N38 28.322 W122 44.408	Low
Novato Bus Yard	801 Golden Gate Place Novato, CA	N38 06.828 W122 34.037	Low
San Francisco Bus Yard	350 8th Street San Francisco, CA	N37 46.463 W122 24.555	Low
Metropolitan Transportation Commission (MTC) - EOC	MetroCenter 101 Eighth Street Oakland, CA 94607	N37 47.818 W122 15.930	Low
Bay Area Rapid Transit (BART)			
Headquarters of BART and the Capitol Corridor Joint Powers Authority	300 Lakeside Drive Oakland, CA	N37˚ 48’32.77” W122˚ 15’47.47”	Low
EOC	101 Eighth Street Oakland, CA 94607	N37 47.818 W122 15.930	Low
Hayward Yard and Shops (Maintenance)	Located at Hayward station 699 B Street Hayward, CA	N37˚ 40’14.49” W122˚ 05’14.25”	Medium
Daly City Yard	500 John Daly Boulevard Daly City, CA	N37˚ 42’18.99” W122˚ 28’10.12”	NA
Richmond Yard	1700 Nevin Avenue Richmond, CA	N37˚ 56’12.14” W122˚ 21’09.47”	NA
Concord Yard	1451 Oakland Avenue Concord, CA	N37˚ 56’26.29” W122˚ 01’41.39”	NA

Entity	Street Address	Coordinates	Probability
Administrative and Storage Buildings			NA
Aerial Structures (24)	Retrofits done but exact location not known		NA
Transbay Tube		N37˚ 48'03.41" W122˚ 22'36.99"	High Poor soils conditions may lead to shutdown
Berkeley Hills Tunnel	Between Rockridge and Orinda stations	N37˚ 51'17.28" W122˚ 12'59.76"	High Passes through Hayward Fault – Potential offset of tunnel
Bored Tunnels, Cut and Cover Tunnels	Unable to identify exact locations		Low
Operating Systems, Equipment and Components	Unable to identify exact locations		Low-Medium
Caltrans – District 4 Headquarters – EOC	111 Grand Ave Oakland, CA 94612	N37 48.682 W122 15.907	Low
AC Transit			
Headquarters	1600 Franklin Street Oakland, CA	N37 48.328 W122 16.138	High
Hayward Bus Facility	1758 Sabre Street Hayward, CA	N37 39.390 W122 07.913	High
East Oakland Bus Facility	1100 Seminary Oakland, CA	N37 45.716 W122 12.246	High
Emeryville Bus Facility - EOC	1177 47th Street Emeryville, CA 94608	N37 50.124 W122 16.963	High
Richmond Bus Facility	2016 McDonald Avenue Richmond, CA	N37 56.147 W122 21.028	High
Central Maintenance Facility	10626 International Boulevard Oakland, CA	N37 44.319 W122 09.975	High
Vallejo Transit Headquarters- Bus Facility and EOC	1850 Broadway Vallejo, CA 94589	N38 08.033 W122 15.141	Medium
Livermore – Amador Valley Transit Authority – Wheels Headquarters – Bus Facility – EOC	1362 Rutan Court, Suite 100, Livermore, California 94551	N37 41.565 W121 48.025	Low
Central Contra Costa County Transit Authority – County Connection Headquarters – Bus Facility – EOC	2477 Arnold Industrial Way, Concord, CA 94520	N38 00.642 W122 01.499	Low - Medium
FERRY SYSTEMS			
San Francisco Bay Area Water Transit Authority Administration and EOC	Pier 9, Suite 111 The Embarcadero San Francisco, CA	N37˚ 48'09" W122˚ 23'.45"	High
Alameda Harbor Bay Service	2 MeCartney Road Alameda, CA, 94502	N37 44.277 W122 15.434 Or N37 44.276 W122 15.486	High

Entity	Street Address	Coordinates	Probability
Alameda Oakland Ferry	Jack London Square 311 Broadway Oakland, CA	N37 47.667 W122 16.549 Or N37 47.638 W122 16.637	High
Angel Island/Tiburon Ferry	Main and Tiburon Boulevard Tiburon, CA	N37 52.411 W122 27.343 Or N37 52.369 W122 27.335	High
Golden Gate Ferry			
Larkspur Ferry Terminal	101 E. Sir Francis Drake Blvd. (at Larkspur Landing Cir.) Larkspur, CA 94904	N37 56.75227, W122 30.687 Or N37 56.602 W122 30.761	Low
Sausalito Ferry Terminal – Loading Dock Only	Bridgeway and Caledonia Street (between Anchor and Napa Streets) or Humboldt and Anchor Streets Sausalito, CA 94965	N37 51.533 W122 28.959	Low
Vallejo Baylink Ferry	289 Mare Island Way Vallejo, CA	N38 06.056 W122 15.761	High
AIRPORTS			
San Francisco International		N37˚ 36'53.03" W122˚ 23'31.49"	Medium-High Runways impacted
Oakland International	1 Airport Drive Oakland, CA	N37˚ 43'09.90" W122˚1 2'31.59"	High Runways impacted
Norman Y. Mineta San Jose International Airport	1661 Airport Boulevard San Jose, CA	N37˚ 21'55.07" W121˚ 55'21.94"	Medium
PORTS			
Port of San Francisco			
Port of San Francisco – Administration - DOC	Pier 1 San Francisco, CA	N37˚ 47'50.89" W122˚ 23'38.65"	Medium
Ferry Building	Embarcadero at the end of Market Street San Francisco, CA	N37 47.735 W122 23.575	Medium
Pier 39		N37 48.529 W122 24.547	Medium
Pier 41	The Pier 41 Ferry Terminal, is located next to Pier 39	N37 48.560 W122 24.726	Medium
Port of San Francisco	Pier 9, 15 and 17 San Francisco, CA	N37˚ 48'09" W122˚ 23'.45"	High
Port of San Francisco	Pier 33, 35 and 45 San Francisco, CA	N37˚ 48'36" W122˚ 24'.20"	High
Port of San Francisco	Pier 30 and 32 San Francisco, CA	N37˚ 47'12" W122˚ 23'.00"	High
Port of San Francisco	Pier 50 and 54 San Francisco, CA	N37˚ 46'24" W122˚ 22'.50"	High
Port of San Francisco	Pier 70 and 80 San Francisco, CA	N37˚ 45'43" W122˚ 22'.47"	High
Port of San Francisco	Pier 90, 92 and 94-96 San Francisco, CA	N37˚ 44'50" W122˚ 22'.48"	High
Port of Oakland			
Port of Oakland - Administration	530 Water Street Oakland, CA	N37˚ 47'43.85" W122˚ 16'43.40"	Medium-High
Port of Oakland	Oakland Inner Harbor Oakland, CA	N37˚ 47'35.68" W122˚ 18'02.94"	High

Entity	Street Address	Coordinates	Probability
Port of Oakland	Oakland Outer Harbor Oakland, CA	N37˚ 49'02" W122˚ 18'56"	High
Port of Redwood City	Wharves 1, 2, 3, 4 and Redwood City Wharf	N37˚ 30'42" W122˚ 12'40"	NA
Port of Richmond			NA
City of Richmond	Terminals No. 1, 2, 4, 7 Wharfs Richmond, CA	N37˚ 57'50" W122˚ 25'41"	NA
City of Richmond Chevron	Long Pier Richmond, CA	N37˚ 55'25" W122˚ 24'40"	NA
City of Richmond	Container Terminal Pier 3 Wharf Richmond, CA	N37˚ 54'50" W122˚ 21'39"	NA
Port of Benicia	Valero-Benicia refinery and Benicia Industries Benicia, CA	N38˚ 02'41" W122˚ 07'45"	NA
INTERCHANGES – STATE ROADWAYS			
I 880 and Highway 238		N37˚ 41'23.61" W122˚ 08'06.38"	High
I 580 and Highway 238		N37˚ 41'24.19" W122˚ 05'56.34"	High
I 580 and Highway 13		N37˚ 50'48.12" W122˚ 17'51.02"	High
I 880 and Highway 92		N37˚ 38'38.43" W122˚ 05'38.47"	High
I 880 and Highway 84		N37˚ 33'46.19" W122˚ 02'19.58"	High
I 980 and I 580		N37˚ 49'24.98" W122˚ 16'03.49"	High
State Bridges	Seismic retrofits	"	Low
Routes 880, 238, 580, 680, 84 and 92	Roadways could be affected - Network damage due to a Hayward fault would be mostly in the Hayward, Castro Valley and San Leandro regions.	"	Low - High
I-580 from San Leandro to Castro Valley	Network damage due to a Hayward fault would be mostly in the Hayward, Castro Valley and San Leandro regions. I-580 would be significantly damaged.	"	High
OTHER FACILITIES			
Coastal Region Regional Emergency Operations Center	1300 Clay Street, Suite 400 Oakland, CA	N37˚ 48'16.26" W122˚ 16'26.14"	High
California Highway Patrol – Golden Gate Division EOC	1551 Benicia Drive Vallejo, CA	N38˚ 05'13.11" W122˚ 12'17.64"	NA
Alameda County Operational Area EOC	4985 Broder Boulevard Dublin, CA	N37˚ 42'57.92" W121˚ 53'24.71"	Low
Contra Costa Operational Area EOC	50 Glacier Drive Martinez, CA	N37˚ 59'23.31" W122˚ 05'14.67"	Medium
Marin Operational Area EOC	3501 Civic Center Drive San Rafael, CA	N37˚ 59'50.88" W122˚ 31'45.26"	NA
San Francisco Operational Area EOC	1011 Turk Street San Francisco, CA	N37˚ 46'52.21" W122˚ 25'32.57"	NA
San Mateo Operational Area EOC	400 County Center Redwood City, CA	N37˚ 29'18.14" W122˚ 13'48.46"	NA
Santa Clara Operational Area EOC	55 W. Younger Avenue, 4th Floor San Jose, CA	N37˚ 20'32.16" W121˚ 54'03.35"	NA

1.9. Effects – Liquefaction

Liquefaction occurs when seismic waves pass through saturated granular soil, distorting its granular structure, and causing some of the empty spaces between granules to collapse. Pore-water pressure may also increase sufficiently to cause the soil to behave like a fluid for a brief period and causing deformations. Liquefaction causes lateral spreads (horizontal movement commonly 10 to 15 feet, but up to 100 feet), flow failures (massive flows of soil, typically hundreds of feet, but up to several miles), and loss of bearing strength (soil deformations causing structures to settle or tip). There are many potential adverse consequences of liquefaction, including small building settlements, larger settlements associated with reduction of foundation bearing strength, and large lateral ground displacements that would tend to shear a building apart.

Figure C.2-9 shows a map of areas in the San Francisco Bay where the liquefaction is likely to occur based on a Hayward earthquake. Figure C.2-10 shows a map of liquefaction in the entire Bay Area, with green indicating liquefaction zones.

Figure C.2-9
Liquefaction Zones

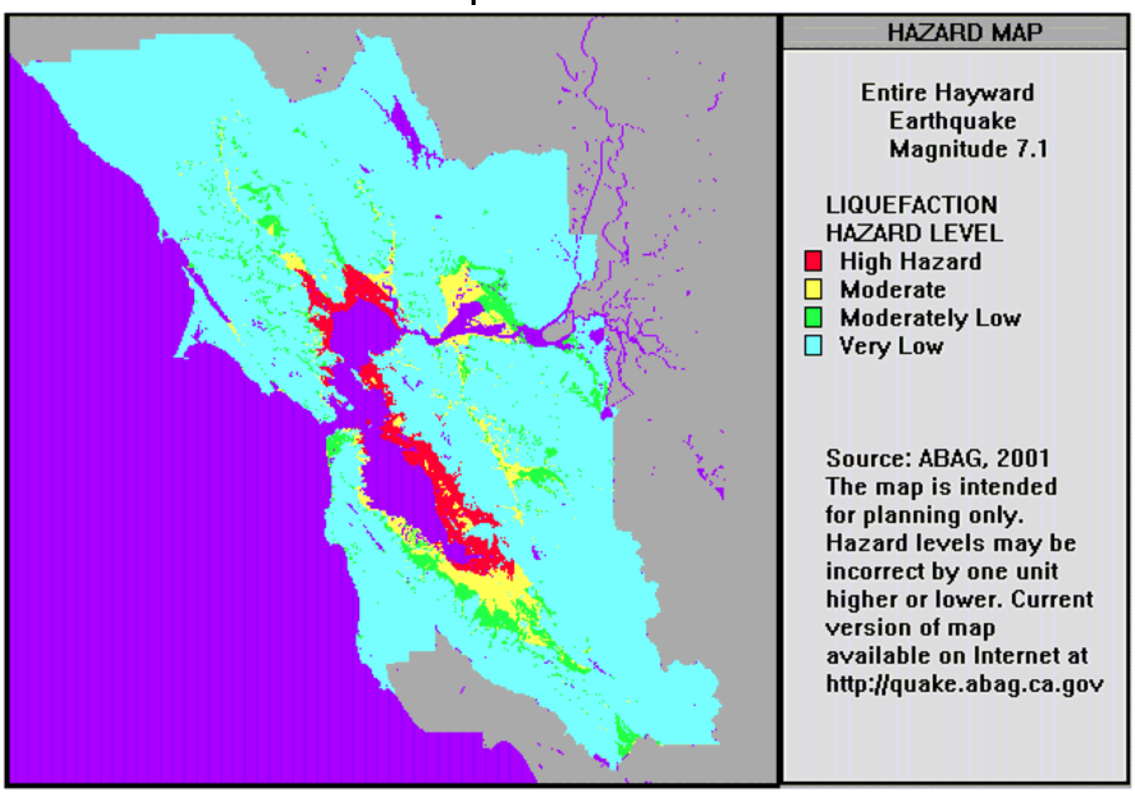
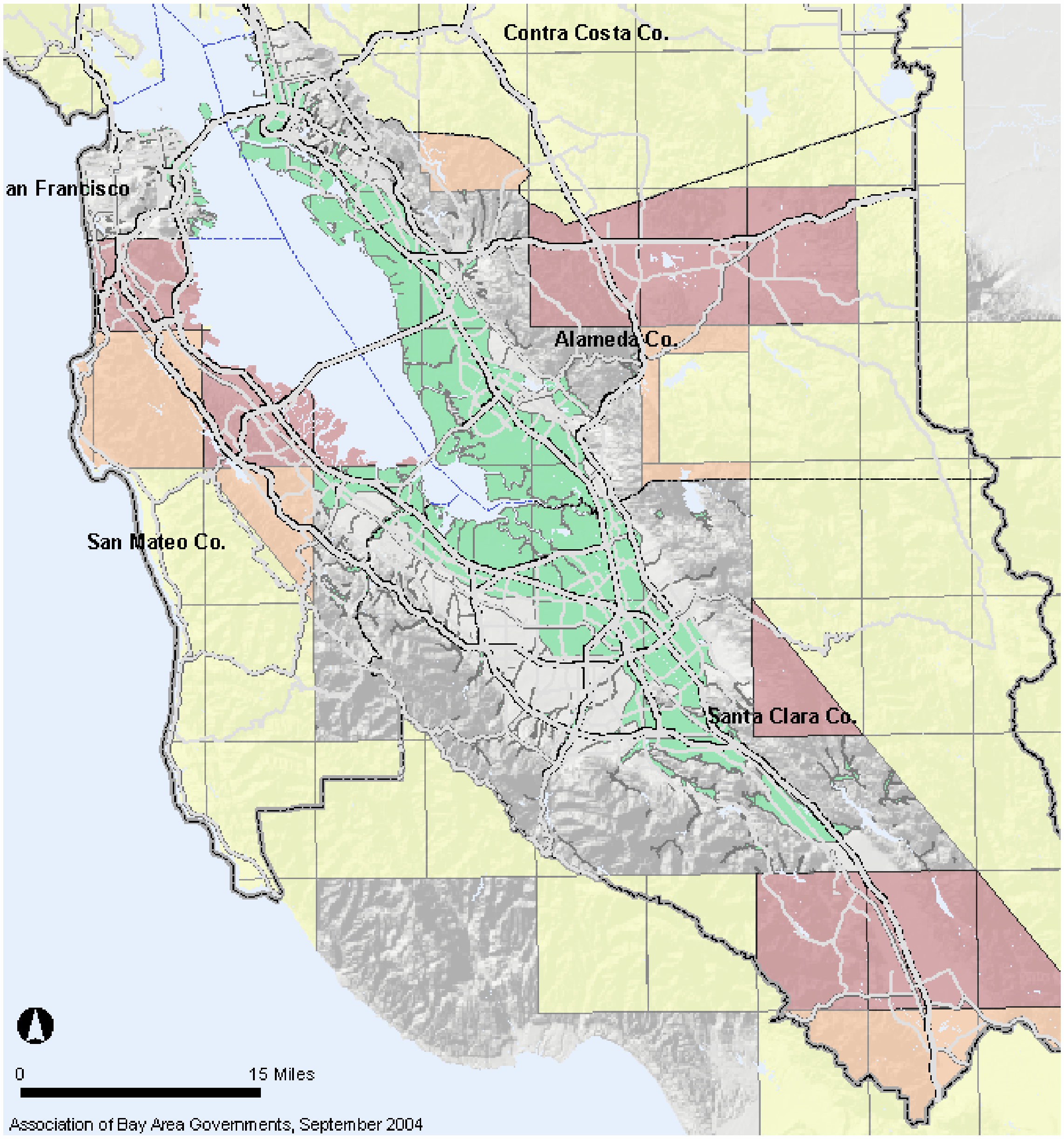


Figure C.2-10
Liquefaction in San Francisco Bay Area



Liquefaction Zones
Areas where historical occurrence of liquefaction, or local geological, geotechnical and ground-water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

Mapping in progress

Mapping planned

Area not yet evaluated

1.10. Transportation Facilities and the Hayward Fault

The following are a series of maps depicting the location of transportation facilities, the location of the Hayward Fault and the shaking in the Bay Area after an earthquake replicating a magnitude 6.9 earthquake.

The first map is an index, followed by smaller maps. The red color indicates the shaking after this earthquake and shows that a number of transportation facilities are located either near the Hayward Fault or are located in areas that will feel the impact of ground level shaking.

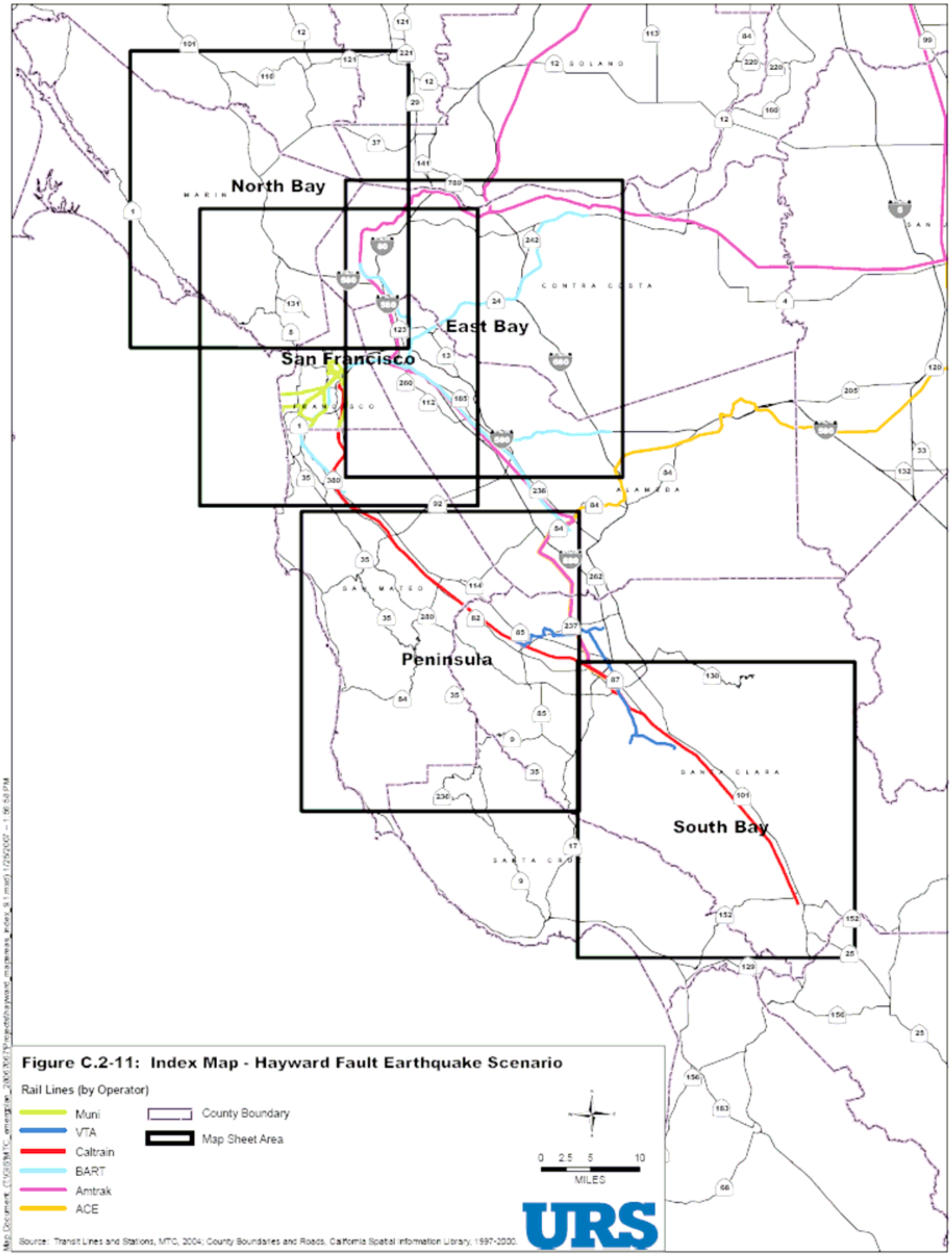


Figure C.2-11: Index Map - Hayward Fault Earthquake Scenario

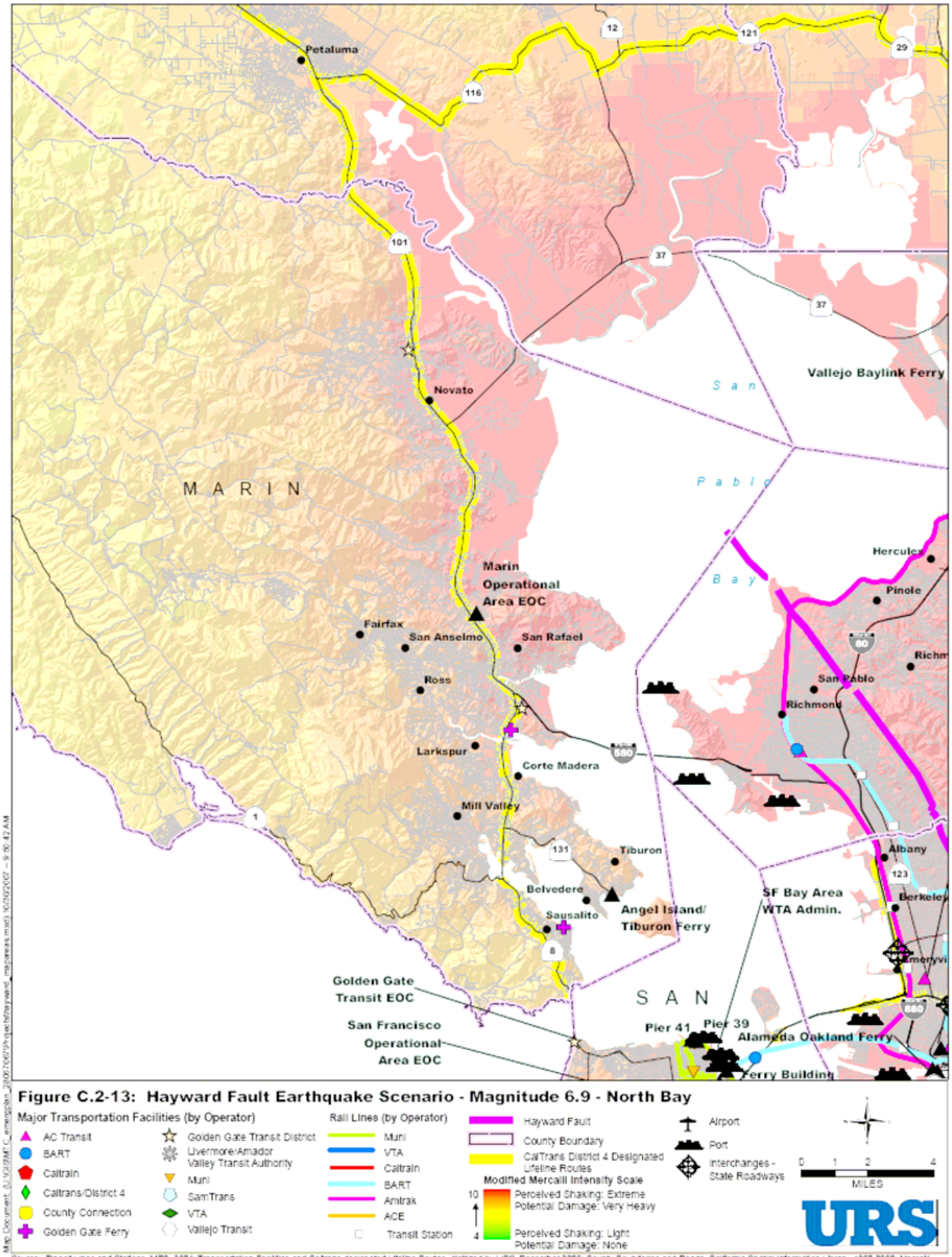


Figure C.2-13: Hayward Fault Earthquake Scenario - Magnitude 6.9 - North Bay

Source: Transit Lines and Stations, MTC, 2004; Transportation Facilities and Caltrans designated Lifeline Routes, digitized by URS, December 2006; County Boundaries and Roads, California Spatial Information Library, 1997-2000; Mercalli Intensity Scale; USGS, March 2003; San Andreas Fault Line, California Division of Mines and Geology, 2000; Shoreline, CASIL, 1997.

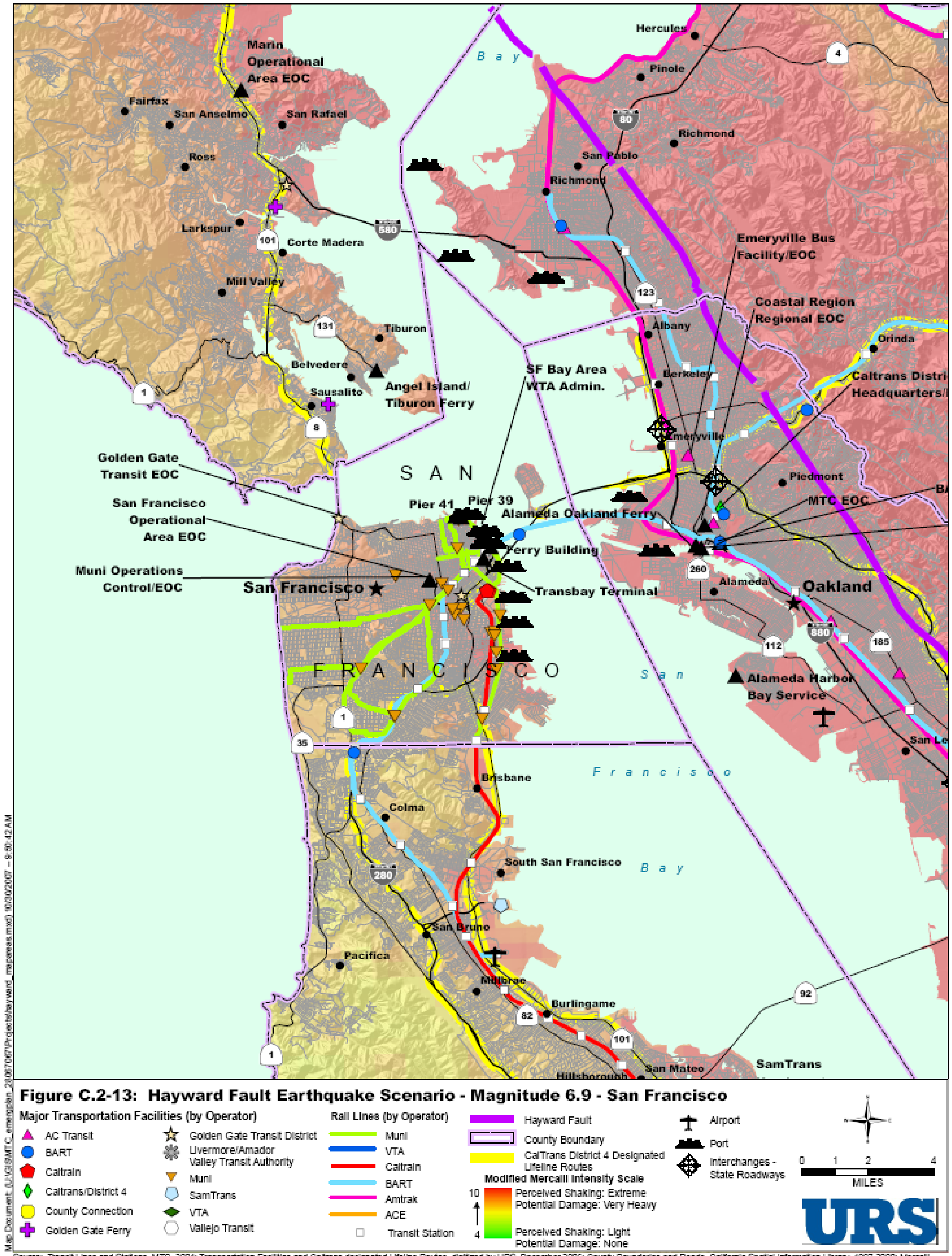


Figure C.2-13: Hayward Fault Earthquake Scenario - Magnitude 6.9 - San Francisco

Source: Transit Lines and Stations, MTC, 2004; Transportation Facilities and Caltrans designated Lifeline Routes, digitized by URS, December 2006; County Boundaries and Roads, California Spatial Information Library, 1997-2000; Mercalli Intensity Scale; USGS, March 2003; San Andreas Fault Line, California Division of Mines and Geology, 2000; Shoreline, CASIL, 1997.

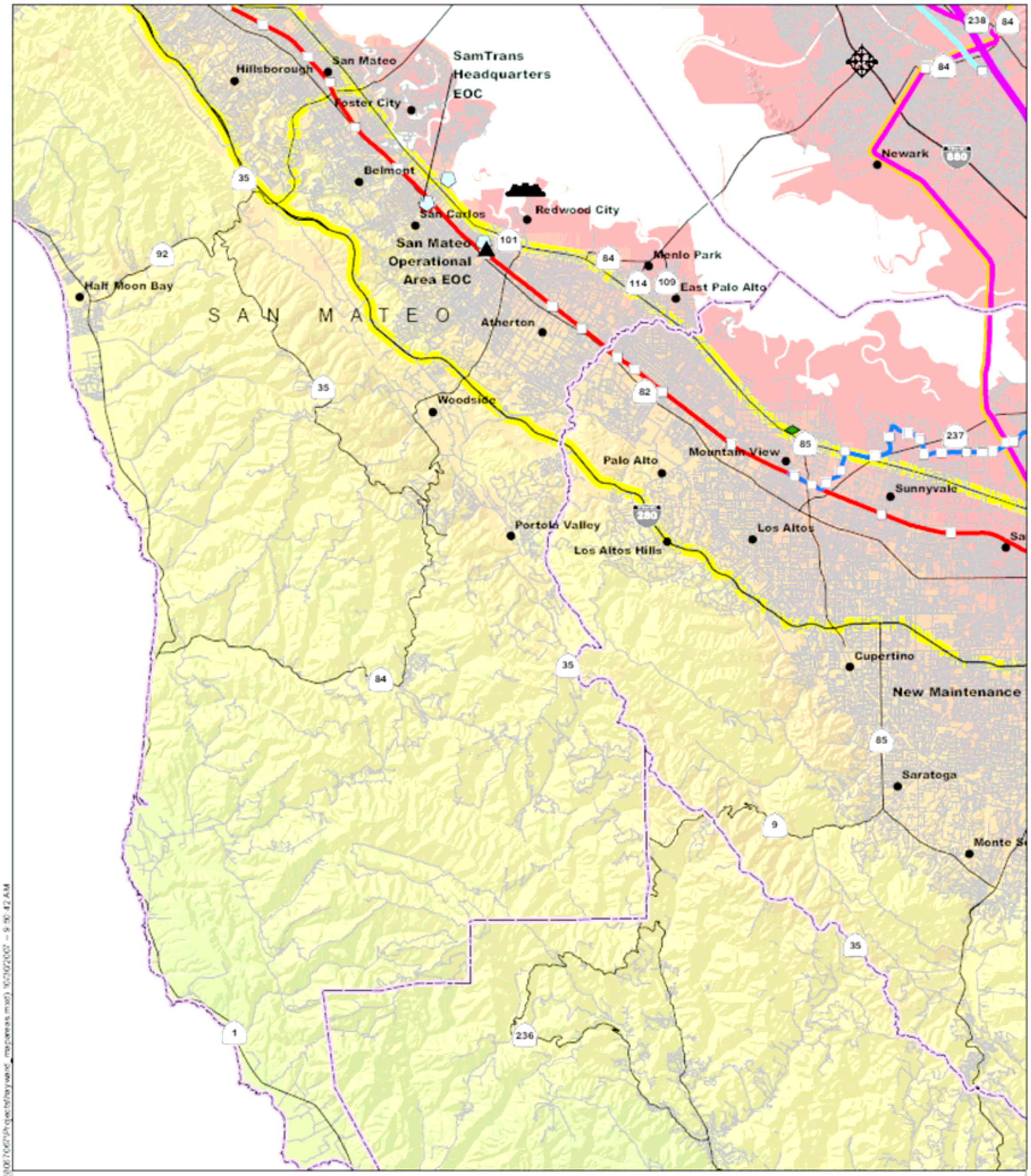


Figure C.2-13: Hayward Fault Earthquake Scenario - Magnitude 6.9 - Peninsula

Source: Transit Lines and Stations, MTC, 2004; Transportation Facilities and Caltrans designated Lifeline Routes, digitized by URS, December 2006; County Boundaries and Roads, California Spatial Information Library, 1997-2000; Mercalli Intensity Scale; USGS, March 2003; San Andreas Fault Line, California Division of Mines and Geology, 2000; Shoreline, CASIL, 1997.

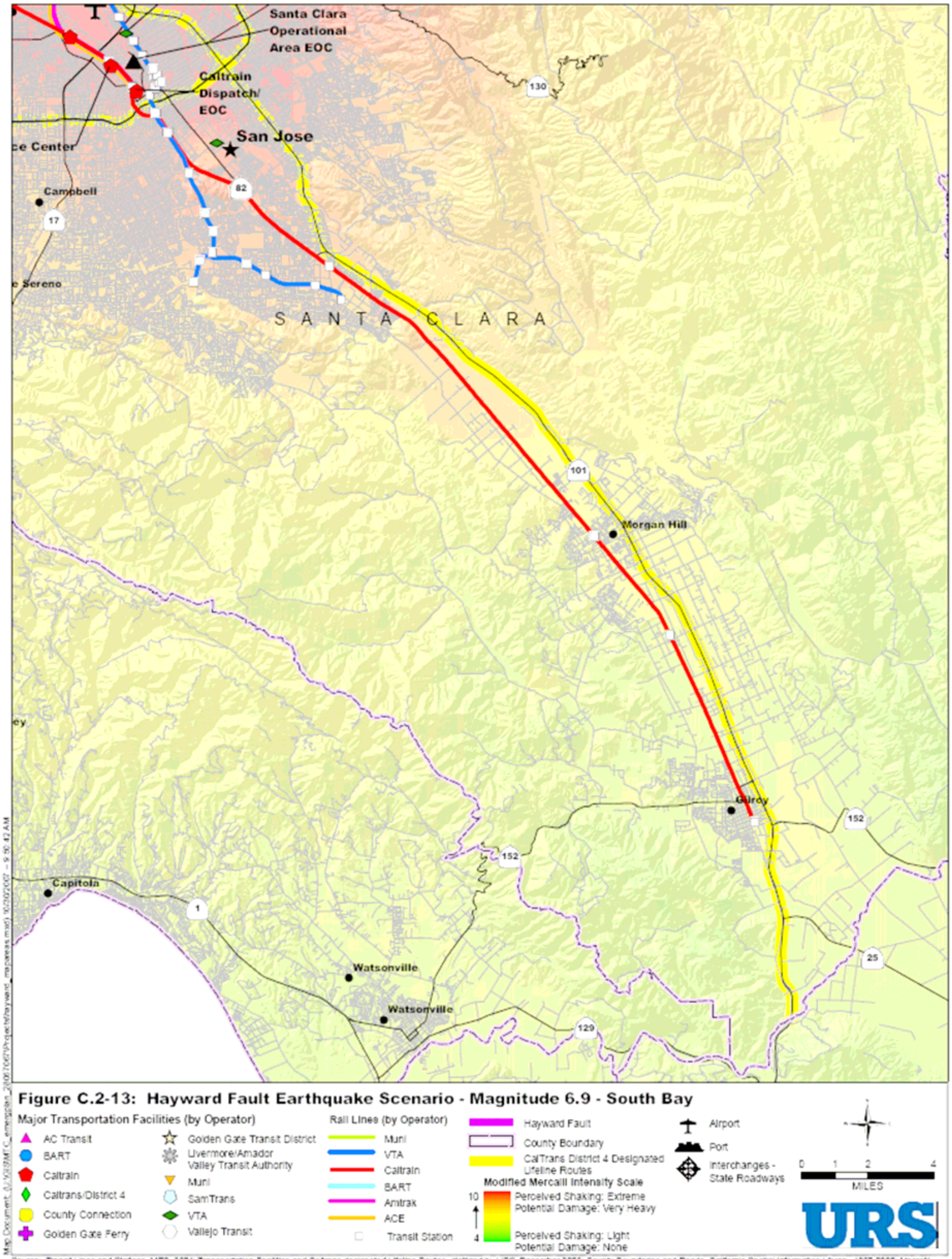


Figure C.2-13: Hayward Fault Earthquake Scenario - Magnitude 6.9 - South Bay

Source: Transit Lines and Stations, MTC, 2004; Transportation Facilities and Caltrans designated Lifeline Routes, digitized by URS, December 2006; County Boundaries and Roads, California Spatial Information Library, 1997-2000; Mercalli Intensity Scale; USGS, March 2003; San Andreas Fault Line, California Division of Mines and Geology, 2000; Shoreline, CASIL, 1997.

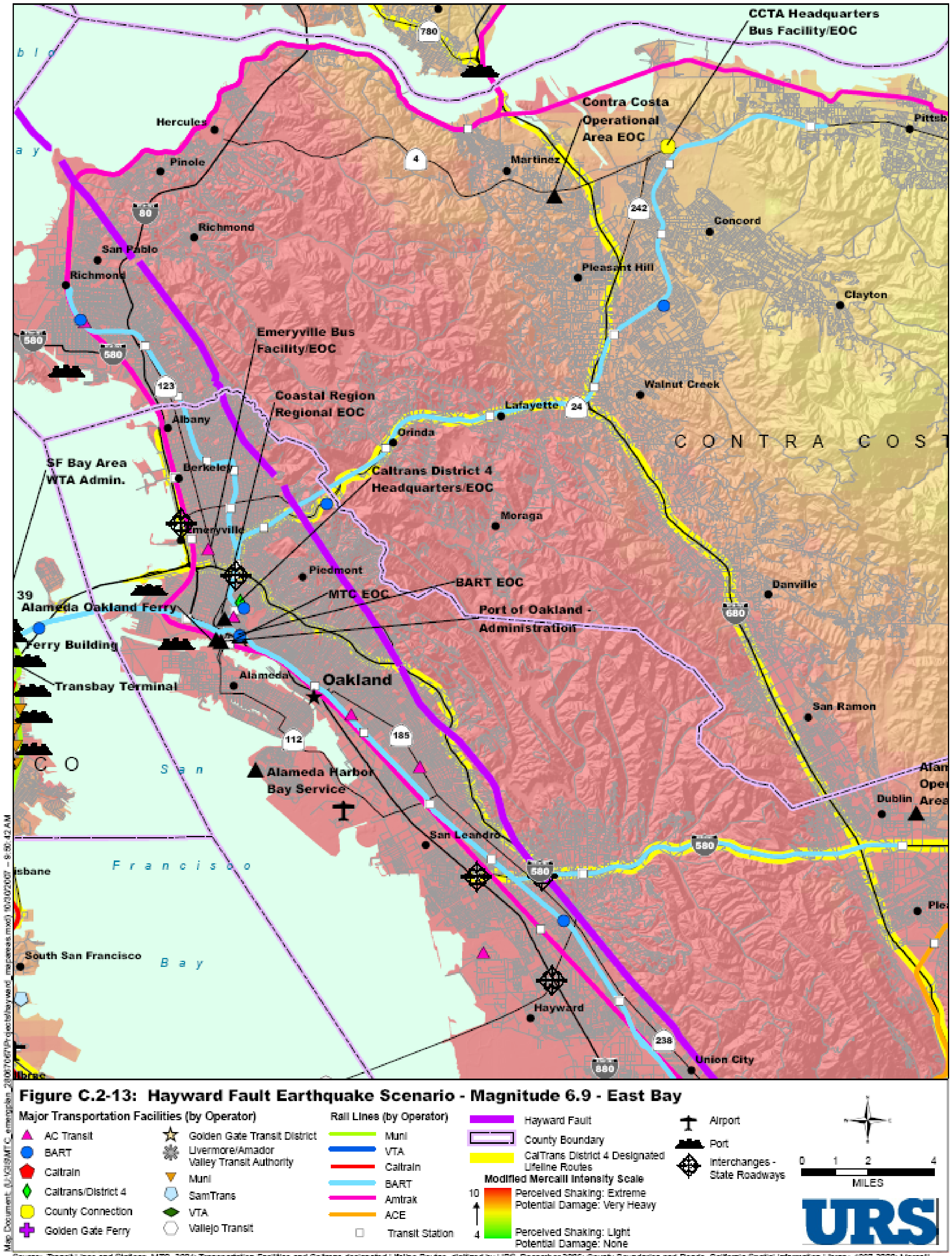


Figure C.2-13: Hayward Fault Earthquake Scenario - Magnitude 6.9 - East Bay

Source: Transit Lines and Stations, MTC, 2004; Transportation Facilities and Caltrans designated Lifeline Routes, digitized by URS, December 2006; County Boundaries and Roads, California Spatial Information Library, 1997-2000; Mercall Intensity Scale; USGS, March 2003; San Andreas Fault Line, California Division of Mines and Geology, 2000; Shoreline, CASIL, 1997.